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Exposure to emotionally arousing, contamination-relevant pictorial stimuli interferes with response inhibition: Implication for obsessive–compulsive disorder

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Abstract

Multiple emotional processes are implicated in the pathogenesis of obsessions and compulsions and individuals diagnosed with obsessive-compulsive disorder (OCD) have reliably shown deficits in response inhibition. Little research has tested how emotional processes might interact with cognitive control in the context of OCD. High contamination obsessive-compulsive (OC) and low contamination-OC participants completed an emotional go/no-go task to measure the interfering effects contamination-threat images relative to neutral images on action restraint (errors of commission). Results revealed that high contamination-OC participants committed marginally more commission errors (11.04%) than low contamination-OC participants (10.30%) on neutral no-go trials, but this effect was not significant ($p > .05$). All participants committed significantly more errors of commission on contamination-threat trials relative to neutral no-go trials, $p < .01$, but the interfering effects of contamination-threat images was significantly larger ($p = .05$) for high-contamination-OC participants. Errors of commission almost doubled for high contamination-OC participants on contamination-threat no-go trials (20.78%), compared to a more modest increase for low contamination-OC participants (14.80%). These findings suggest that individuals with elevated symptoms of OCD may have significantly more difficulty inhibiting their actions when processing disorder relevant or emotionally arousing information. This observation has implications for the pathogenesis of obsessions and compulsions.

Keywords

inhibition; emotion; obsessive; compulsive; cognitive control

Introduction

Theoretical and empirical literatures suggest failures of cognitive control may partially underlie the pathogenesis and acute exacerbation of obsessions and compulsions (Schultz, Evans, & Wolff, 1999). Multiple studies have reported that individuals diagnosed with Obsessive-Compulsive Disorder (OCD) evince impaired performance on tests designed to

measure response inhibition when compared to both healthy and anxious controls (Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005; Rosenberg & Keshavan, 1998). For example, meta-analyses suggest that individuals diagnosed with OCD perform much worse ($g = .77$) on the stop-signal task – a measure of action cancellation – relative to healthy controls (Lipszyc & Schachar, 2010). Similarly, several studies have shown that individuals diagnosed with OCD commit more errors of commission during go/no-go tasks – a measure of action restraint – when compared to healthy and anxious controls (Aycicegi, Dinn, Harris, & Erkmen, 2003; Bannon, Gonsalvez, Croft, & Boyce, 2002; Penades et al., 2007; Watkins et al., 2005). Importantly, response inhibition findings are notoriously mixed across studies, samples, and methods (Greisberg & McKay, 2003) and multiple studies have failed to detect significant deficits in response inhibition among subjects diagnosed with OCD (Bohne, Savage, Deckersbach, Keuthen, & Wilhelm, 2008; Page et al., 2009; Watkins et al., 2005).

Evidence suggests that visual exposure to emotionally provocative stimuli interferes with response inhibition (De Houwer & Tibboel, 2010; Verbruggen & De Houwer, 2007). For example, De Houwer and Tibboel (2010) demonstrated that exposure to pictures that were high in emotional arousal interfered with action restraint – as measured by an emotional go/no-go task – and that pictures that were high in emotional arousal and negatively valenced interfered more than neutral pictures. De Houwer and Tibboel provided an attentional account of their findings. They proposed that the effortful act of stopping a prepotent responses is dependent on attention being directed at said task. Processing of emotional stimuli can draw attention away from a variety of effortful tasks (Shimmack & Derryberry, 2005). Emotional stimuli can, therefore, interfere with inhibitory processes when said stimuli are sufficiently arousing to draw attention from the task of stopping. Indeed, this was what was reported by in both studies by De Houwer's group; the presentation of emotionally arousing stimuli immediately prior to stopping tasks increased errors of commission (De Houwer & Tibboel, 2010) and increased stop-signal reaction time (Verbruggen & De Houwer, 2007). If the attentional account of emotional interference of response inhibition is correct, then interfering effects of emotionally arousing stimuli on response inhibition should be greater among populations with attentional biases toward emotionally arousing information.

OCD patients and analogue samples of obsessive-compulsive participants, especially those reporting contamination/washing symptoms, have reliably shown attentional biases toward disorder relevant information (Summerfeldt & Endler, 1998). An effect that is likely due to prolonged maintenance on or difficulty disengaging attention from disorder-relevant stimuli (Armstrong, Olatunji, Sarawgi, & Simmons, 2010; Armstrong, Sarawgi, & Olatunji, 2012; Cisler & Olatunji, 2010; Olatunji, Ciesielski, & Zald, 2011). Accordingly, the interfering effects of emotionally arousing, disorder relevant stimuli on response inhibition should be intensified among participants diagnosed with OCD and those reporting elevated obsessions and compulsions. Meaning, once attention is drawn to the arousing stimuli performance on tasks that require substantial attentional allocation – such as most response inhibition tasks – should be handicapped. No research has directly tested how affective factors might contribute to difficulties with response inhibition among obsessive-compulsive samples (Krikorian, Zimmerman, & Fleck, 2004). This is particularly noteworthy given that clinical

examples of failed response inhibition among OCD patients occur in emotionally arousing situations that typically contain multiple emotionally arousing stimuli. Take, for example, compulsive hand washing, which can be explained by a strong motivation to wash *and* a failure to resist or stop washing (i.e., failures of inhibition). The internal and contextual features that motivate washing are emotionally salient, capture and hold patient's attention, and may interfere with inhibition of washing behaviors.

The present study addresses gaps in the extant literature by testing how presentation of emotionally arousing, contamination-relevant stimuli interference with action restraint. The study utilized two quasi-experimental participant groups: 1) an obsessive-compulsive group who endorsed elevated contamination/washing symptoms [high-contamination obsessive-compulsive (OC)], and 2) a low-contamination-OC group control who endorsed minimal obsessions and compulsions (including minimal contamination/washing symptoms). Participants completed a symptom-specific version of the emotional go/no-go task, which was designed to experimentally test the interfering effects of contamination-threat stimuli on action restraint. The present study utilized a 2 (Group: obsessive-compulsive vs. low-contamination-OC) $\times$ 2 (Threat: contamination-threat vs. neutral] mixed factorial design. It was predicted that: 1) visual exposure to contamination-threat stimuli prior to task performance would interfere with action restraint; 2) high-contamination-OC participants would evidence poorer action restraint than low-contamination-OC participants; and 3) the interfering effects of contamination-threat would be greater among high-contamination-OC participants relative to low-contamination-OC participants. Additional variables were also analyzed for exploratory purposes, including: errors of omission (not going on go trials), no-go RT (latency of key press on no-go trials), and go RT (latency of key press on go trials).

Methods

Materials

Emotional Go/No-Go—(Figure 1). Go/no-go tasks require participants to go (e.g., press a spacebar) following the presentation of one stimulus (i.e., go symbol) and to restrain from going following the presentation of a second stimulus (i.e., no-go symbol). The proportion of trials that a participant fails to restrain (error of commission) relative to the proportion of successfully restrained trials provides a measure of the participant's ability to inhibit prepotent actions. As such, more commission errors reflect poorer action restraint. The present study employed a modified version of the emotional go/no-go detailed by De Houwer and Tibboel (2010).

Practice and test trials started with the presentation of a 12cm $\times$ 11cm white rectangle in the center of the screen. After 500 ms, a picture appeared in the center of the rectangle for 250 ms. This is the same stimulus duration that was used in the only other study that tested if presentation of emotionally arousing pictures interferes with action restraint (De Houwer & Tibboel, 2010). The picture then offset and a go or no-go symbol [$\$$ or # were counterbalanced as go or no-go symbols across participants] appeared in the middle of the screen until the participant responded or until 400 ms elapsed. If the participant did not respond within 400 ms on a go trial, then "TOO SLOW" appeared on the screen for 200 ms. Feedback on go trials was provided to stress the importance of speed and to better ensure

that participants did not strategically delay responses. This likely resulted in more errors of commission than if no feedback were provided. Each new trial began 600 ms after a response or feedback.

The emotional go/no-go began with a block of 24 practice trials. Six neutral (low arousal, neutral valence) images were selected from the International Affective Picture Set (Lang, Bradley, & Cuthbert, 1999) for practice trials. Neutral pictures were followed by the go symbol 12 times and the no-go symbol 12 times. If a participant received more than 6 “TOO SLOW” warning messages during practice, then the experimenter had the participant complete another practice block. This was done to stress the importance of speed to participants who appeared to strategically slow their responding to prevent errors of commission. No participant was required to complete more than 2 practice blocks.

Participants then completed 2 test blocks, each starting with 6 warm-up trials followed by 96 test trials. The warm-up trials were randomly drawn from the practice block. Twelve contamination-threat and 12 neutral pictures were utilized as interference stimuli during test trials. The contamination-threat pictures used in the present study have been rated as more unpleasant, arousing, fearful, and disgusting than the neutral picture set (Armstrong et al., 2012).¹ These pictures are likely to be highly arousing and negatively valenced, much like those used by De Houwer and Tibboel (2010) that also interfered with action restraint. Each of the 24 test-trial pictures was presented 8 times and was followed by the go symbol and the no-go symbol an equal number of times. This resulted in a total of 192 test trials [48 test trials per trial type (neutral go, neutral no-go, contamination-threat go, and contamination-threat no-go trials)]. The order of test trials was determined randomly within each test block for each participant. The primary dependent variable, errors of commission, was measured via proportion of errant key presses on no-go trials relative to the total number of no-go trials. Secondary variables included errors of omission (proportion of response errors on go trials), go RT (average response latency on go trials), and no-go RT (average response latency on no-go trials). All 4 of the emotional go/no-go variables were calculated across each of the two threat categories (contamination-threat vs. neutral).

Dimensional Obsessive Compulsive Scale—(DOCS) (Abramowitz et al., 2010) is a 20-item, self-report measure that assesses severity of four symptom dimensions of OCD [5-items each: contamination, responsibility, unacceptable thoughts, and symmetry].

Cronbach’s alpha was high for the DOCS-Total score ($\alpha = .96$) and moderate to high for all DOCS subscales (range = .87 - .93) within the present sample.

Generalized Anxiety Disorder – 7—(GAD-7) (Spitzer, Kroenke, Williams, & Lowe, 2006) is a 7-item, self-report measure used to assess levels of trait anxiety over the last 2 weeks. The GAD-7 total score ranges from zero to 21. Cronbach’s alpha of the GAD-7 was .81 within the present sample.

¹Subjective disgust and anxiety ratings of pictorial stimuli (i.e., 0 = not at all to 9 = completely) were requested from all participants at the end of the experiment. Due to procedural errors, data were not recorded or obtained from all participants or for all pictures. Available data ($n_{\text{high-contamination-OC}} = 12$ and $n_{\text{low-contamination-OC}} = 29$) suggest that contamination-threat images were more disgust ($M = 6.91$, $SD = .66$) and anxiety ($M = 6.89$, $SD = 1.45$) provoking than neutral pictures ($M_{\text{anxiety}} = .65$, $SD_{\text{anxiety}} = .67$; $M_{\text{disgust}} = .66$, $SD_{\text{disgust}} = .75$) (all $ps < .001$).

Participants

Participants with DOCS-Contamination and DOCS-Total scores greater than or equal to 7 and 18, respectively, were included in the high-contamination-OC group. Inclusion in the low-contamination-OC group required DOCS-Contamination and DOCS-Total scores less than or equal to 3 and less than 18, respectively. Previous research has shown that a DOCS-Total score of 18 is highly sensitive and specific for distinguishing between OCD patients and a student sample (Abramowitz et al., 2010). This same study reported a mean DOCS-Contamination score of 6.53 ($SD = 6.4$) among OCD patients and a mean DOCS-Contamination score 2.03 ($SD = 2.89$) among a student sample. As such, the present study's cut-off scores ensured that high-contamination-OC participants had significant symptoms of OCD and elevated contamination obsessions and washing compulsions while also ensuring that these symptoms were significantly less severe among low-contamination-OC participants.

Seven hundred eighty six Introductory Psychology students at a large southern university were pre-screened using the DOCS-Contamination subscale (only the DOCS-Contamination items were administered due to cost and page restrictions) and only those with DOCS-Contamination scores ≥ 7 or ≤ 3 ($n = 86$) were invited to complete the full DOCS. From those who completed the full DOCS, 18 high-contamination-OC and 31 low-contamination-OC participants scored above or below the aforementioned DOCS-Contamination and DOCS-Total cut-off scores during the in-person testing session. High-contamination-OC and low-contamination-OC participants did not significantly differ in age, race, or gender (Table 1). High-contamination-OC participants scored much higher than low-contamination-OC participants on all DOCS subscales and the GAD-7, all $ps < .01$ (Table 1). Nearly all low-contamination-OC participants reported single digit DOCS-Total scores ($range = 0 - 15$, $M = 6.47$) while all high-contamination-OC participants reported DOCS-Total scores of 20 or more ($range = 21 - 49$, $M = 30.65$). Moreover, between group differences in DOCS-Total and DOCS-Contamination scores were very large (*Cohen's d* = 3.9 and 4.83, respectively). These data suggest that high-contamination-OC participants had much more severe symptoms of OCD, especially contamination/washing symptoms, and were more anxious than low-contamination-OC participants.

Procedures

All participants were tested individually in a dark 6x8 room. Pictorial stimuli were presented on a 36cm by 29cm flat screen monitor set at a 1280x1024 resolution and 60 hz refresh rate. The emotional go/no-go task was programmed and administered using Inquisit software (Millisecond Software). Each experimental session began with the completion of an IRB-approved informed consent. Participants then completed the emotional go/no-go task followed by a questionnaire battery. All participants were offered and provided class credit toward a course requirement or \$20 cash as compensation for their participation.

Results

Multilevel modeling (MLM) was utilized to test hypotheses. MLM has fewer and less strict assumptions than ANOVA (including mixed ANOVA). The present study utilized a between-

within design with markedly unequal sample sizes on the between-subjects factor. Equal sample sizes and homogeneity of variance on the between subject's factor is not required for MLM (Raudenbush & Bryk, 2002). Moreover, MLM provides a powerful method for analyzing experimental psychopathology data, particularly data that are hierarchically structured or tasks that involve responses that are not independent across a within-subjects factor (i.e., such as the Threat factor of the present study) (Field & Wright, 2011).

Maximum likelihood was used to calculate parameter estimates. Models were specified in an iterative fashion, whereby fixed and random factors were individually added to the baseline (null) model to ensure that the final model evidenced improved goodness of fit relative to the baseline model. For each DV, models were specified and compared in the following order: 1) baseline model; 2) level 1 (Threat), 3) level 2 (Threat and Group), and 4) full model (Threat, Group, and Threat by Group) (Field & Wright, 2011). Threat was modeled as a fixed and repeated effect while the intercept was modeled as a random and fixed effect, Group was modeled as a fixed effect, and the Group by Threat interaction was modeled as a fixed effect. All analyses were carried out with SPSS 20 (IBM Corp.).

Data from the emotional go/no-go were inspected and cleaned according to the standards outlined by De Houwer and Tibboel (2010). Reaction times below 150 ms were removed. This resulted in the removal of less than 1% of all data. One participant from each group was excluded from analyses as their data were indicative of poor effort or strategic performance. These participants committed errors of omission on more than 50% of go trials.

The full model was the best fitting model for errors of commission (Table 2). When collapsed across Threat and Group, participants committed errors of commission on an average of 13.76% of no-go trials. The main effect of Threat was significant, $F(1, 47) = 31.13$, $p < .01$, suggesting that, when collapsed across Group, participants committed more errors of commission on contamination-threat no-go trials than neutral no-go trials. The main effect of Group was not significant $F(1, 47) = 1.82$, $p = .18$, suggesting that, when collapsed across Threat, high-contamination-OC participants did not commit significantly more errors of commission than low-contamination-OC participants. Finally, the Threat by Group interaction effect was significant $F(1, 47) = 4.21$, $p < .05$, suggesting that the effects of Threat were greater for high-contamination-OC participants than low-contamination-OC participants (Figure 2).²

Contrast analyses revealed that the errors of commission on neutral trials did not significantly differ between groups ($p = .78$, $d = 0.08$). High-contamination-OC participants committed only 0.74% more errors of commission ($\beta_{group} = 0.74$, $SE = 2.68$) than low-contamination-OC participants on neutral no-go trials, whom committed errors of commission on 10.30% on neutral no-go trials ($\beta_{intercept} = 10.30$, $SE = 1.61$). Low-contamination-OC participants committed significantly more (4.5% more) errors of commission on contamination-threat compared to neutral no-go trials ($\beta_{threat} = 4.50$, $SE = 1.53$, $p < .01$, $d = 0.86$). But high-contamination-OC participants committed nearly twice as

²Errors of commission were also analyzed with mixed ANOVA. Effects were largely the same. The Group by Threat effect was marginally significant ($p = .051$), the Threat effect was significant ($p < .01$), and the Group effect was not significant ($p = .19$).

many (9.74% more) errors of commission on contamination-threat compared to neutral no-go trials ($\beta_{threat} = 9.73$, $SE = 2.04$, $p < .01$, $d = 1.39$).

There were no significant effects of Threat, Group or Threat by Group on go RT (Table 2). There was a significant main effect of Threat on no-go RT (Table 2). No-go RT was 12.78 ms faster on contamination-threat trials, but this effect did not differ between low-contamination-OC and high-contamination-OC participants. Lastly, there was a significant effect of Threat on errors of omission (Table 2). Participants committed 3.8% more errors of omission on contamination-threat trials but this effect did not differ between low-contamination-OC and high-contamination-OC participants.

Discussion

The present study was focused on how visual exposure to emotionally arousing, contamination-relevant pictorial stimuli interfered with action restraint among an analogue sample of obsessive-compulsive participants. This sample was particularly relevant to the questions at hand given the large body of research suggesting that failures of response inhibition, various emotional factors, and attentional biases are implicated in the pathogenesis of obsessions and compulsions. Consistent with the findings of De Houwer and Tibboel (2010), the present study showed that exposure to emotionally arousing information prior to no-go trials increased failures of action restraint (errors of commission) among both quasi-experimental groups. As a novel extension, the present study showed that the proportion of errors of commission almost doubled for high-contamination-OC participants on contamination-threat no-go trials, but only increased by approximately 50% for low-contamination-OC participants. This suggests that the degree to which emotionally arousing stimuli can interfere with response inhibition might be greater when said stimuli are more relevant to the person or among populations with attentional biases toward particular types of stimuli.

Contamination-threat images likely provoked anxiety and disgust and drew the attention of all participants, particularly those endorsing elevated contamination obsessions and washing compulsions (Armstrong et al., 2012). However, the present study design does not allow for any conclusions about the specific psychological processes that were responsible for the interfering effects or the between-group differences in the degree of interference. The contamination-threat images lack process specificity and could have provoked a variety of psychological processes and, therefore, a variety of psychological processes might have interfered with action restraint. In keeping with the theory proposed by De Houwer and Tibboel (2010), it is possible that the degree to which contamination-threat pictures captured and maintained attention is at least partially responsible for increased failures of action restraint. Future research should aim to directly test the attentional account by measuring attentional biases along with response inhibition using the same task stimuli. Moreover, and if the attentional account of the present findings is true, then emotionally arousing stimuli should interfere with a variety of cognitive tasks so long as the stimuli are presented immediately prior to or along with task response stimuli. The present findings Research should continue exploring the variety of ways in which emotion and attention are implicated in most cognitive tasks, including response inhibition.

The absence of the Group effect on errors of commission was unexpected. The simplest explanation for this finding is that the present study was not sufficiently powered. Indeed, the effect was trending in the expected direction and there was a relatively small number of high-contamination-OC participants. It is also possible that high-contamination-OC participants in the present sample have milder deficits in response inhibition than individuals diagnosed with OCD. However, high-contamination-OC participants in the present sample all scored above the clinical cut-off score identified by Abramowitz and colleagues (2010) and scored higher than the clinical sample reported by Abramowitz and colleagues. This suggests that a sizeable majority of high-contamination-OC participants (approximately 75% given specificity of the DOCS) would likely meet DSM diagnostic criteria for OCD. Most go/no-go research utilizes a much greater proportion of go relative to no-go trials (e.g., 80/20) to increase error rates. It is possible that the equal proportion of go to no-go trials in the present study reduced error rates, which may also be responsible for the absence of a Group effect. Indeed, previous go/no-go research in which no-go trials were less common than go trials (i.e., 27% vs. 73%) reported far more errors of omission (e.g., 47% among OCD and 22% among control subjects; Penades et al., 2007) than were reported in the current study for neutral no-go trials.

Given the absence of a non-OCD anxious control group, it is possible that the present findings are partly due to general anxiety and not obsessive-compulsive symptoms. However, previous response inhibition research has failed to document meaningful relation between measures of trait anxiety and either neutral or emotional response inhibition (Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009). Nonetheless, it will be important for future replications and extensions to examine comorbidity and clinical diagnosis in larger samples.

The emotional go/no-go used in the present study had a time pressure that may have artificially cut off errors of commission that occurred after 400 ms. This is, however, an unlikely explanation as average go RT and no-go RT were well below 400 ms. The go/no-go is also an easier task than other measures of response inhibition (Verbruggen & Logan, 2008). Perhaps Group effects would have been more evident with a more difficult task such as the emotional stop-signal tasks used by Verbruggen and De Houwer (2007) or Pessoa and colleagues (2012).

The present study only utilized two types of interference stimuli, neutral and contamination-threat. It is possible that disorder irrelevant, but threatening stimuli may have also interfered with inhibition. Indeed, previous research has clearly shown that highly arousing and negatively valenced pictures interfere with action restraint more than neutral pictures (De Houwer & Tibboel). Future research should include emotionally arousing stimuli that are not disorder specific to test if generic emotional stimuli or disorder specific emotionally arousing stimuli cause more interference among individuals with elevated OC symptoms.

The likely personal relevance of the contamination-threat images to high-contamination-OC participants may have also contributed to the increased interference effect. Relatedly, the diversity of contamination fears (e.g., dirt, germs, illness, chemicals) would suggest that the contamination-threat images used in the present study were not personally relevant to all

participants. Future research should use ideographic interference stimuli and collect subjective ratings of personal relevance to better account for or assess the effects of personal relevance. Moreover, the use of additional comparison groups with interference stimuli that are relevant to them (e.g., sad images with depressed patients) could help address the issue of disorder specificity.

It is important to consider that inhibition does not occur in a vacuum (Pessoa, 2008; Verbruggen & De Houwer, 2007). In the case of OCD, inhibition often fails during emotionally provocative situations. Emotionally salient cues (e.g., toilet) may trigger emotionally arousing intrusive thoughts (e.g., fear of illness) that may impair attempts to suppress unwanted thoughts. Compulsions, much the same, are motivated by exposure to emotionally arousing stimuli and resultant negative affect. Internal and external cues not only increase motivation for compulsive behaviors, but may also interfere with the ability to restrain from engaging in or prematurely stopping said behaviors. This interaction of emotion, attention, and cognitive control may help explain why, for example, compulsive washers have difficulty resisting or stopping cleaning compulsions. This is an important idea as engagement in compulsive behaviors has been shown to maintain and even exacerbate severity of OCD (Deacon & Maack, 2008) and ritual prevention is a necessary component of cognitive-behavioral therapy for OCD (Foa, Steketee, & Milby, 1980). Future research should assess how performance on tasks such as the one used in the present study predict behavioral indices of obsessions and compulsions or predict response to CBT for OCD.

References

- Abramowitz JS, Deacon BJ, Olatunji BO, Wheaton MG, Berman NC, Losardo D, Hale LR, et al. Assessment of obsessive-compulsive symptom dimensions: Development and evaluation of the Dimensional Obsessive-Compulsive Scale. *Psychological assessment*. 2010; 22(1):180–198. DOI: 10.1037/a0018260 [PubMed: 20230164]
- Armstrong T, Olatunji BO, Sarawgi S, Simmons C. Orienting and maintenance of gaze in contamination fear: Biases for disgust and fear cues. *Behaviour research and therapy*. 2010; 48(5): 402–408. DOI: 10.1016/j.brat.2010.01.002 [PubMed: 20138252]
- Armstrong T, Sarawgi S, Olatunji BO. Attentional bias toward threat in contamination fear: Overt components and behavioral correlates. *Journal of abnormal psychology*. 2012; 121(1):232–237. DOI: 10.1037/a0024453 [PubMed: 21707123]
- Aycicegi A, Dinn WM, Harris CL, Erkmén H. Neuropsychological function in obsessive-compulsive disorder: Effects of comorbid conditions on task performance. *European Psychiatry*. 2003; 18(5): 241–248. DOI: 10.1016/S0924-9338(03)00065-8 [PubMed: 12927325]
- Bannon S, Gonsalvez CJ, Croft RJ, Boyce PM. Response inhibition deficits in obsessive-compulsive disorder. *Psychiatry research*. 2002; 110(2):165–174. DOI: 10.1016/S0165-1781(02)00104-X [PubMed: 12057828]
- Bohne A, Savage CR, Deckersbach T, Keuthen NJ, Wilhelm S. Motor inhibition in trichotillomania and obsessive-compulsive disorder. *Journal of Psychiatric Research*. 2008; 42(2):141–150. DOI: 10.1016/j.jpsychires.2006.11.008 [PubMed: 17215004]
- Chamberlain SR, Blackwell AD, Fineberg NA, Robbins TW, Sahakian BJ. The neuropsychology of obsessive compulsive disorder: the importance of failures in cognitive and behavioural inhibition as candidate endophenotypic markers. *Neuroscience and biobehavioral reviews*. 2005; 29(3):399–420. DOI: 10.1016/j.neubiorev.2004.11.006 [PubMed: 15820546]
- Cisler JM, Olatunji BO. Components of attentional biases in contamination fear: Evidence for difficulty in disengagement. *Behaviour research and therapy*. 2010; 48(1):74–78. DOI: 10.1016/j.brat.2009.09.003 [PubMed: 19781691]

- Deacon B, Maack DJ. The effects of safety behaviors on the fear of contamination: An experimental investigation. *Behaviour Research and Therapy*. 2008; 46(4):537–547. [PubMed: 18313031]
- De Houwer J, Tibboel H. Stop what you are not doing! Emotional pictures interfere with the task not to respond. *Psychonomic bulletin & review*. 2010; 17(5):699–703. DOI: 10.3758/PBR.17.5.699 [PubMed: 21037169]
- Derakshan N, Ansari TL, Hansard M, Shoker L, Eysenck MW. Anxiety, inhibition, efficiency, and effectiveness. *Experimental Psychology (formerly Zeitschrift für Experimentelle Psychologie)*. 2009; 56(1):48–55. DOI: 10.1027/1618-3169.56.1.48
- Field AP, Wright DB. A primer on using multilevel models in clinical and experimental psychopathology research. *Journal of Experimental Psychopathology*. 2011; 2(2):271–293. DOI: 10.5127/jep.013711
- Foa EB, Steketee G, Milby JB. Differential effects of exposure and response prevention in obsessive-compulsive washers. *Journal of Consulting and Clinical Psychology*. 1980; 48(1):71. [PubMed: 7365045]
- Krikorian R, Zimmerman ME, Fleck DE. Inhibitory control in Obsessive-Compulsive Disorder. *Brain and cognition*. 2004; 54(3):257–259. DOI: 10.1016/j.bandc.2004.02.038 [PubMed: 15050788]
- Kroenke K, Spitzer RL, Williams JBW, Monahan PO, Löwe B. Anxiety disorders in primary care: prevalence, impairment, comorbidity, and detection. *Annals of Internal Medicine*. 2007; 146(5):317–325. DOI: 10.7326/0003-4819-146-5-200703060-00004 [PubMed: 17339617]
- Lang PJ, Bradley MM, Cuthbert BN. International affective picture system (IAPS): Technical manual and affective ratings. 1999
- Lipszyc J, Schachar R. Inhibitory control and psychopathology: A meta-analysis of studies using the stop signal task. *Journal of the International Neuropsychological Society*. 2010; 16(6):1064–1076. DOI: 10.1017/S1355617710000895 [PubMed: 20719043]
- Moritz S, Birkner C, Kloss M, Jacobsen D, Fricke S, Bothern A, Hand I. Impact of comorbid depressive symptoms on neuropsychological performance in obsessive-compulsive disorder. *Journal of abnormal psychology*. 2001; 110(4):653–658. DOI: 10.1037/0021-843X.110.4.653 [PubMed: 11727955]
- Olatunji BO, Ciesielski BG, Zald DH. A selective impairment in attentional disengagement from erotica in obsessive-compulsive disorder. *Progress in neuro-psychopharmacology & biological psychiatry*. 2011; 35(8):1977–1982. DOI: 10.1016/j.pnpbp.2011.07.005 [PubMed: 21801779]
- Page LA, Rubia K, Deeley Q, Daly E, Toal F, Mataix-Cols D, Murphy DGM, et al. A functional magnetic resonance imaging study of inhibitory control in obsessive-compulsive disorder. *Psychiatry Research: Neuroimaging*. 2009; 174(3):202–209. DOI: 10.1016/j.pscychresns.2009.05.002 [PubMed: 19906516]
- Penades R, Catalan R, Rubia K, Andres S, Salamero M, Gasto C. Impaired response inhibition in obsessive compulsive disorder. *European psychiatry : the Journal of the Association of European Psychiatrists*. 2007; 22(6):404–410. DOI: 10.1016/j.eurpsy.2006.05.001 [PubMed: 17127038]
- Pessoa L. On the relationship between emotion and cognition. *Nature Reviews Neuroscience*. 2008; 9(2):148–158. [PubMed: 18209732]
- Raudenbush, Stephen W.; Bryk, Anthony S. Hierarchical linear models: Applications and data analysis methods. Vol. 1. Sage; 2002.
- Rosenberg DR, Keshavan MS. Toward a neurodevelopmental model of obsessive-compulsive disorder. *Biological psychiatry*. 1998; 43(9):623–640. DOI: 10.1016/S0006-3223(97)00443-5 [PubMed: 9582996]
- Schultz RT, Evans DW, Wolff M. Neuropsychological models of childhood obsessive-compulsive disorder. *Child and adolescent psychiatric clinics of North America*. 1999; 8(3):513–531. [PubMed: 10442229]
- Schimmack U, Derryberry DE. Attentional interference effects of emotional pictures: threat, negativity, or arousal? *Emotion*. 2005; 5(1):55. [PubMed: 15755219]
- Spitzer RL, Kroenke K, Williams JBW, Lowe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of Internal Medicine*. 2006; 166(10):1092–1097. DOI: 10.1001/archinte.166.10.1092 [PubMed: 16717171]

- Summerfeldt LJ, Endler NS. Examining the evidence for anxiety-related cognitive biases in obsessive-compulsive disorder. *Journal of anxiety disorders*. 1998; 12(6):579–598. DOI: 10.1016/S0887-6185(98)00035-8 [PubMed: 9879037]
- Verbruggen F, De Houwer J. Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion*. 2007; 21(2):391–403. DOI: 10.1080/02699930600625081
- Verbruggen F, Logan GD. Automatic and controlled response inhibition: Associative learning in the go/no-go and stop-signal paradigms. *Journal of Experimental Psychology: General*. 2008; 137(4): 649–672. DOI: 10.1037/a0013170 [PubMed: 18999358]
- Watkins LH, Sahakian BJ, Robertson MM, Veale DM, Rogers RD, Pickard KM, Robbins TW, et al. Executive function in Tourette's syndrome and obsessive-compulsive disorder. *Psychological medicine*. 2005; 35(4):571–582. DOI: 10.1017/S0033291704003691 [PubMed: 15856727]

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Figure 1.

Pictorial display of the emotional go/no-go task used in the present study.

Note. Neutral trials were identical save for the fact that low arousal, low valence pictures were used in place of contamination-threat pictures. Go and No-Go symbols were counterbalanced across all participants.

Figure 2.

Main effects and interaction of Threat (neutral and contamination-threat) and Group (low-contamination-OC and high-contamination-OC) on errors of commission.

Note. Exposure to contamination-threat pictures increased errors of commission for both groups. The interfering effects of contamination - threat pictures was significantly greater among participants endorsing elevated obsessive-compulsive symptoms.

Table 1

Descriptive data for low obsessive-compulsive (Control) and Obsessive-Compulsive (OC) participants.

	Low-Cont.-OC (<i>M</i>, <i>SD</i>)	High-Cont.-OC (<i>M</i>, <i>SD</i>)	<i>F</i> or χ^2
DOCS-Total	6.47 (.72)	30.65 (8.70)	172.06 ^{<i>b</i>}
DOCS-Contamination	1.53 (.18)	9.47 (2.32)	265.88 ^{<i>b</i>}
DOCS-Responsibility	1.97 (.31)	8.12 (2.87)	85.24 ^{<i>b</i>}
DOCS-Obsessions	1.74 (.32)	7.12 (2.62)	71.63 ^{<i>b</i>}
DOCS-Symmetry	1.41 (.26)	5.94 (4.41)	29.38 ^{<i>b</i>}
GAD-7	2.77 (1.83)	6.47 (3.62)	21.78 ^{<i>b</i>}
Age	19.07 (.94)	19.65 (2.32)	0.23
Gender	67% Female	59% Female	0.29
Race	83% Caucasian	82% Caucasian	1.99

Note.

^{*a*} denotes p .05

^{*b*} denotes p .01

Table 2

AIC values for all models and go/no-go measurement variable.

	Errors of Commission	Errors of Omission	No-Go RT	Go RT
Baseline	696.59 ICC = .41	700.01 ICC = .66	851.82 ICC = .29	745.17 ICC = .64
Level 1: Threat	679.52	693.70	846.88	747.69
Level 2: Group	680.32	695.39	848.76	746.74
Full: Threat by Group	678.28	697.23	848.35	750.46

Note. Level 2 model of Go RT was estimated without the effect of threat. Interclass correlations are also included to show adequate variance within DVs.